Promises and Pitfalls of Reference Wetlands in Forested Ecosystem Restoration

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Restoring degraded ecosystems is a major new focus of research and practice (National Research Council 1992; Cairns 1995) but the scientific basis for ecological restoration is thin. Restoration of bottomland hardwood forests is the subject of considerable interest in the southern United (Clewell and Lea 1990; Sharitz 1992; Noss et al. 1995) although there is little consensus on what constitutes restoration success. Many authors stress the need for clear objectives in a restoration project, in order that indicators of restoration success can be specified (e.g., Anderson and Dugger 1998). Most practitioners seem to favor the use of reference stands (Brinson and Rheinhardt 1996). Restoration guidelines usually recommend identifying older, relatively undisturbed reference stands as the criteria for successful restoration (Clewell and Lea 1990).

In this paper, I present an overview of how reference stands may be used in restoration research and practice, drawing upon experience from bottomland hardwood restoration. Reference sites are used in restoration practice primarily for as criteria for success, or less rigorously for setting expectations. I will discuss the limitations of reference sites for both these uses, and conclude by suggesting ways to overcome limitations.

In my view, there are many uses for well-studied reference sites. In research, reference sites are critical for long-term ecological and silvicultural research, which is the basis for restoration practice. In addition, reference stands can be used to develop modal points in classifications and in creating habitat templates, which allow us to transfer detailed understanding of a few reference sites to the multiplicity of sites requiring restoration. Reference sites can be used in multiple ways to develop process models, which in turn aid in predicting whether restoration interventions will succeed. These include conceptualizing, calibrating, and validating our models.

Beyond research, reference sites have uses that are more mundane. Monitoring efforts should use reference sites, for both project monitoring and for assessing long-term trends such as Forest Health Monitoring. A special hybridization of modeling and monitoring, environmental impact assessment, is a popular pastime in the U.S. In wetlands regulation, references sites are used in setting Mitigation Ratios directly or through Functional Indices under the Hydrogeomorphic Assessment (HGM) technique.

In restoration work, reference sites are used for setting expectations and for defining criteria for success. Although there are drawbacks to using reference sites to measure success, they may be useful in defining goals. A restoration site, once developed, should fit within the range of species composition and stand structure for that forest type, as it occurs in the vicinity (Clewell and Lea 1990). Hydroperiod restoration should aim at establishing a diversity of sites within the range of wetland types in the landscape (Bedford 1996). Reference sites can be chosen which represent target conditions for the restoration site. Care must be taken, however, to establish a hydrological record for both the restoration and reference sites. When comparing the restoration and reference stands, one should always take into account temporal variability of stand conditions. We have to recognize that there often are multiple pathways of stand development and functional attributes such as biodiversity will change over time (Oliver and Larson 1996). Disturbance regimes and past land use can dramatically influence present vegetation of reference stands (Parker and Pickett 1997).

Reference sites have limitations as indicators of success. The most common application is in the Restored-Reference Model (R-R). The critical assumptions of the R-R model are that the restored site changed, the changes were caused by restoration treatments, and the reference sites provide

realistic expectations (Anderson and Dugger 1998). The first assumption is often violated, as there are seldom pre-treatment data for the restored site. In addition, both the reference and the restored site are open systems, subject to external regulation, and changes can be due to something other than treatments. Whether reference sites provide realistic expectations is a matter of spatial and temporal variation. Every site is unique at some level, and the similarity of two sites decreases as distance between them increases. Lack of similarity increases more rapidly for composition than for structure, and for rare and infrequent species.

Can reference sites be used less rigorously for setting expectations? Expectations are targets, the desired future conditions. One limitation is that reference sites may provide only a partial sample of the range of a function, especially if remnant natural areas are used as references. Other factors include the effects of management on a reference site. In many cases fires have been excluded. Harvesting may have selectively removed or retained species, and usually will have altered stand structure. In bottomlands, a particular concern is for hydroperiod alteration, which can result from landuse change elsewhere in a basin, and from several natural or anthropogenic factors. Climatic variation and extreme events in the past or future need to be considered (Devall and Parresol 1998).

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